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REPORT NO. 12-7-50G-1

MONTHLY PROGRESS REPORT

ENGINEERING PROGRAM FOR THE DEVELOPMENT OF A LIGHTWEIGHT ANTI-TANK ROCKET

FOR THE PERIOD

MONTH OF DECEMBER 1957

CONTRACT NO. RD-142

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FLIGHTEX FABRICS, INC.

PROGRESS REPORT #4

ENGINEERING PROGRAM FOR THE DEVELOPMENT OF A LIGHTWEIGHT ANTI-TANK ROCKET

DECEMBER 1957

CONTRACT NO. RD-142

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CAMBRIDGE, MASSACHUSETTS

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WORK DONE DURING THE MONTH OF DECEMBER 1957

REPORTING PERIOD 7 DECEMBER TO 10 JANUARY 1958

SYSTEM EVALUATION PROGRAM

During December a flight test was held which showed the round (E. M. No. 1) to be sufficiently accurate at 100 yard range at a conditioning temperature of (plus) 120° F. All seven rounds of the control group fell within a rectangle 2 1/2 feet horizontally and 3 feet vertically. Unfortunately, the accuracy tests at -20° F were plagued by motor failures. Some of the motors were being used for the fourth time. As a result, only a three-round group could be obtained at the cold temperature. Although this group gave an indication of satisfactory accuracy, no conclusion can be made due to the small sample size. All rounds fired showed proper ignition, while those rounds with eight folding fins had good flight stability over the entire trajectory. Metal parts to provide 200 rounds of E. M. No. 2 have been placed in manufacture. Delivery of these parts will coincide with receipt of propellant about the end of January or the early part of February.

Fifty copper liners with increased wall were manufactured during December. Continuing the investigation of the low penetration achieved in the first static test, it was found that the tolerance between the head body and copper liner was large enough to introduce the possibility of misalignment upon assembly. To eliminate this possibility, the tolerances between liner and head body of E. M. No. 2 were changed to a 0 to .005" interference fit. Twenty-five heads of E. M. No. I are presently being carefully assembled and should be statically tested in January. Static tests with these heads was not possible in December as originally planned due to the decision to selectively assemble head body and liners to obtain the best possible fit, thereby not jeopardizing the penetration results because of misalignments.

During December a working model was made of the redesigned launcher. This model is currently being tested and evaluated. It is expected that the model will be sufficiently satisfactory to permit the manufacture of a quantity of launchers for statistical dynamic testing.

The problems associated with the introduction of the rotor to the fuze mechanism were solved during December. A flight test was held with five complete fuzes, and all fuzes functioned satisfactory. Two hundred sets of fuze parts are currently being manufactured in order to carry out extensive statistical tests as soon as rounds and propellant become available.

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MOTOR DEVELOPMENT PROGRAM

During December flight tests were held at 100 yard range which showed the accuracy of the round to be satisfactory at the ≠ 120° F conditioning temperature. The seven rounds of the control group all fell within a rectangle 2 1/2 feet by 3 feet. Within the control group were rounds having dissimilar characteristics, i.e., some had six, others had eight fins; some had steel, others had aluminum nozzles. Also, no attempt was made to match weight between rounds. When all rounds are identical and when closer weight tolerances are observed, it may be expected that accuracy will be better than already observed.

As a part of this same flight test, rounds were fired at - 20° F conditioning temperature. Unfortunately, only three rounds of this group could be used to evaluate accuracy. Although these three rounds appeared satisfactory, no conclusion can be made due to the small sample. However, based on the satisfactory results obtained at the higher temperature, partially substantiated by the small group at the lower temperature, it is felt that future flight tests at the lower temperature will be satisfactory.

Following is a table showing the characteristics of the test rounds and a brief comment on their flight behavior:

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TABLE OF ROUND CHARACTERISTICS

Round #	Cond. Temp.	No. of Fins	Fuze	Nozzle Insert	Comment
51	$+ 120^{\circ}F$	8	Yes	Al	Stable
52	$+ 120^{\circ}F$	8	Yes	St	Stable
53	$+ 120^{\circ}F$	8	Yes	St	Stable, heavy round, hit low
54	$+ 120^{\circ}F$	6	Yes	St	Slight wobble
55	$+ 120^{\circ}F$	8	Yes	St	Stable
56	$+ 120^{\circ}F$	6	Yes	Al	Stable
57	$+ 120^{\circ}F$	6	No	Al	Light round, hit high, stable
58	$+ 120^{\circ}F$	6	No	Al	Light round, hit high, stable
59	$+ 120^{\circ}F$	6	No	Al	Stable
60	$- 20^{\circ}F$	8	No	Al	Stable
61	$- 20^{\circ}F$	8	No	Al	Motor failed
62	$- 20^{\circ}F$	8	No	St	Stable, launcher not zeroed, missed target
63	$- 20^{\circ}F$	6	No	Al	Stable
64	$- 20^{\circ}F$	6	No	Al	Motor failed
65	$- 20^{\circ}F$	8	No	St	Stable, launcher not zeroed
66	$- 20^{\circ}F$	6	No	St	Not fired, threads seized
67	$- 20^{\circ}F$	8	Yes	Al	"
68	$- 20^{\circ}F$	6	Yes	Al	Stable, some yaw at target

As shown in the table two motors failed at the cold temperature. Such failures are to be expected since these motors have all benn fired at least three, and some four, times before. The failure of the motors at the cold temperature instead of the hot is characteristic. Motor failure is dependent upon both pressure and time, and although pressure is much higher at the higher temperature, the time of burning is so short that literally the motor does not have time to react to the higher pressure before the pulse is over. However, at the colder temperature, not only is the material more susceptible to failure (shock) due to embrittlement but the pressure is applied over a period of time sufficiently long for the metal to be plastically deformed. It should be pointed out that the motor failures which have occurred are no cause for concern since they have only happened after repeated use of the motor and also since the material used as a substitute for 2024 T-3 has a tensile strength of about half of that for 2024 T-3. The next lot of motors, currently being manufactured, are being made from 2024 T-3.

Drawing No. A8244 in the appendix shows the target hits of all rounds on a 10' X 10' target. The number in parenthesis after each round shows the number of fins for that round. Based on an evaluation of round grouping vs. number of fins, and also on the observation that some rounds with six fins wobbled somewhat towards the end of their flight (see preceding table), it may be concluded that rounds with six fins exhibit marginal stability while those with eight fins show satisfactory stability. Therefore, all future rounds will have eight fins.

The following table shows the ballistic characteristics of all rounds. Velocity, impulse and specific impulse continue to be satisfactory:

FLIGHT DATA - BALLISTICS COMPUTATION SHEET

ROUND NO.	51	52	53	54	55	56	57	58	59
VELOCITY (FT/SEC)	345	345	323	345	335	335	385	400	335
PROP. WT. (LBS.)	.132	.132	.132	.132	.132	.132	.132	.132	.132
1/2 PROP. WT.	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
PROJECTILE WT.	3.34	3.42	3.5	3.44	3.36	3.38	2.99	3.00	3.15
EFF. WT. (4 + 5)	3.40	3.48	3.56	3.5	3.42	3.44	3.05	3.06	3.21
IMP. $\frac{(6 \times 2)}{g}$	36.6	37.5	35.9	37.7	35.8	36.	36.2	37.6	33.6
SPEC. IMP. $\frac{7}{3}$	277	284	272	286	271	273	274	285	254
TEMP 0 F	+ 120	+ 120	+ 120	+ 120	+ 120	+ 120	+ 120	+ 120	+ 120

REMARKS:

Round Nos. 57, 58 used to check strength of Aluminum launcher tube.

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(Continued)

ROUND NO.	60	61	62	63	64	65	68
VELOCITY (FT/SEC)	345		345	345	Motor Failure	304	345
PROP. WT. (LBS.)	.132		.132	.132	"	.132	.132
1/2 PROP. WT.	0.06		0.06	0.06		0.06	0.06
PROJECTILE WT.	2.99	3.02	3.26	3.12	3.08	3.28	3.25
EFF. WT. (4 + 5)	3.05		3.32	3.18		3.34	3.31
IMP. $\frac{(6 \times 2)}{g}$	32.4		35.8	34.3		31.4	35.7
SPEC. IMP $\frac{7}{3}$	245		271	260		238	270
TEMP O F	-20	-20	-20	-20	-20	-20	-20

REMARKS:

NOTE: Round No. 61 separated in flight.

Round Nos. 66, 67 not fired; threads locked upon assembly giving only 1 1/2 to 2 threads engagement.

Round No. 68 - tail dipped slightly through flight.

With the completion of the accuracy test in December, the first major phase of the round development has been completed. A table is currently being prepared which will show data on all rounds fired to date. This table will be included in next month's progress report. In order to orient the Project Officer with the current status of the program, a brief summary of accomplishments to date (pertaining to the motor development) is given below.

By re-use of the original lot of 25 motors, data has been gathered leading to the determination of:

1. Propellant charge configuration.
2. Igniter charge and geometry.
3. Fin geometry to obtain stability.

Small test samples have shown E. M. No. 1 to possess satisfactory velocity and accuracy characteristics. Based on observation of E. M. No. 1, E. M. No. 2 has been designed and is currently being manufactured. The next major phase of the project will start when testing begins with large sample groups of E. M. No. 2. The purpose of this phase will be to show statistical proof of satisfactory round characteristics, such as velocity and accuracy. (These rounds will also give similar statistical proof of the characteristics of the HEAT head, fuze, and launcher.) It is expected that E. M. No. 2 will be, with perhaps minor modifications, the final item. The testing with E. M. No. 2 should begin about the beginning of February, 1958, and continue for two months until about the first or middle of April. Minor modifications

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will then be made, and a final lot of rounds placed in manufacture for tests during July and August, 1958.

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WARHEAD DEVELOPMENT PROGRAM

Manufacture of the fifty increased wall liners, discussed in last month's report, was completed during December. In an endeavor to insure better penetration, Mr. Nelson A. was consulted regarding assembling methods. In his opinion the tolerances between the O. D. of the liner and the I. D. of the head body may have been sufficiently large to result in a misalignment between the liner and body. If this hypothesis is correct, it would account to a large extent for the double jets observed in previous tests. Accordingly, the tolerances on E. M. No. 2 were changed to provide for an 0 to .005" interference fit between the liner and head body. Upon assembly, the head body is heated for soldering and the resulting expansion allows the cone to drop into place.

Unfortunately, twenty-five heads of E. M. No. 1 had already been manufactured before the tolerances could be changed. In order to make proper use of these heads, it was decided that assembly would be done by Mr. A. who would match liners with head bodies so as to obtain the best possible fit. Also, inspection fixtures would be made to determine quantitatively the alignment of liner and body after assembly. Generally speaking, extreme measures are being taken to insure the best possible assembly, and as a result, the time for assembly will be longer than anticipated. It is expected that the heads will be ready

next 25 static tests will be new liners with E. M. #1 head bodies

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for loading about the end of January, 1958. A static penetration test will follow as soon as possible thereafter.

Metal parts for the HEAT head of E. M. No. 2 are being manufactured. Delivery is expected about the first of February.

LAUNCHER DEVELOPMENT PROGRAM

Photograph No. 32 in the appendix shows the igniter test adapter and accessories. This adapter can be placed in the rear of the launcher and permits laboratory testing of the igniter and firing mechanism of the launcher. A 22 blank will be used as a primer for the initiation of the black powder charge. In laboratory tests the criteria for a successful test will be the setting off of the 22 blank. Black powder will be added in range tests.

Photograph No. 33 shows the orientation of the firing pin and the restraining plunger. As may be seen, the design has been somewhat changed from what was described in last month's report. Instead of slotting the end of the restraining plunger, the end is left rounded and the firing pin is machined to rest on the rounded end of the plunger.

Photograph No. 34 shows some of the completed components prior to assembly on the launcher. The safety handle is not shown since some modifications were being made to it at the time of the photograph. The trigger guard, as shown in Photograph No. 34 has been modified to allow more room for the trigger finger. The modification may be seen in Photograph No. 35.

The safety handle is shown in the storage (safe) and in the ready (for firing) positions in Photograph No. 35 . The action of the restraining plunger stop (located at the rear of the trigger linkage) is demonstrated in Photograph Nos. 36 and 37.

During January functioning and handling tests will be run, after which a quantity of 100 sets of components will be ordered for comprehensive range testing. The range testing should take place sometime in February.

In order to establish a criteria which could be used to manufacture launchers of the proper strength,,several flight tests were run during December using an aluminum launcher. The wall of the launcher was success vely reduced from .100" to .040" with no failure or deformation occurring. Further reduction of the wall was impractical from a machining viewpoint. Furthermore, sufficient data had been obtained for establishing a criteria. The company manufacturing the launchers has been informed that a minimum requirement is that the launcher have the same strength characteristics as those of aluminum tubing (6061 T-6) having a .040" wall.

FUZE DEVELOPMENT PROGRAM

INTRODUCTION

The problems which appeared in the previous reporting period were evaluated. Of the various possible solutions, two were picked out and tried. Static tests were conducted with the improved design. One of the improved concepts was tested dynamically and proved to be successful. It can therefore be stated that the reason for the malfunctions experienced in November have been eliminated.

EVALUATION OF THE PROBLEM

In both static and dynamic tests in December the following condition was observed:

The firing pin would be found in the partly armed or completely unarmed rotor. The inertia element had set back and latched properly. The fuze thus could not arm. There are two possible reasons for this:

1. That the triggering components separate during their backward travel.

2. That the triggering components set back and lock properly but that excessive overtravel exists (see September report for definition

of overtravel) so that the deceleration of the triggering sleeve when latching occurs is of a sufficiently high order to overcome the friction caused by the balls. If this condition exists and the duration of the decelerating force acting on the triggering sleeve is too long, the firing pin will be released when latching occurs. This would cause it to fire into the unarmed rotor.

The cause for the first condition could be friction between the wall of the fuze housing and the triggering sleeve. The fact that the firing pin is preventing the rotor from turning may enter into the picture since the rotor torque spring has the tendency to push the firing pin over to one side.

The second condition could arise if there is too much overtravel or if the relative hardness of the parts is such as to produce a bouncing effect. This may be counteracted by increasing the mass of the triggering sleeve versus the mass of the inertia element.

In evaluating the problem, the thought came to mind that the first condition could be eliminated by making the inertia element extend forward and form a shroud around the triggering sleeve. This would eliminate relative motion between the triggering sleeve and its surrounding wall during set back. This concept led to the double ball design shown both in Photograph No.38 and Drawing No. C8162.

Here three balls reach into a groove in the triggering sleeve. They are contained in three suitable holes in the inertia element. The depth of the groove is designed in such a way that the triggering sleeve cannot be separated from the inertia element unless the balls can move out. When the triggering components have set back, they reach a groove in the wall of the housing which allows the balls to come out and release the triggering sleeve which is then held only by the friction caused by the firing spring and the balls engaging the firing pin. This approach was considered promising, and it was decided to go ahead with it and to try the shroud without the locking balls later if the basic concept seems to solve the problem. The design, Drawing No. C8162, was detailed and components ordered for testing.

The set-back force relationship between the triggering sleeve and the inertia element was also considered of some importance, and a new design, Drawing No. C8157, developed. This also was detailed and components were prepared for testing. (see Photograph No. 41).

In addition, modified triggering sleeves were prepared. The modifications consisted in decreasing the height of the sleeve and decreasing the O. D. The effect of such a change is that the firing pin is further forward when in the safe position. It goes back to the identical latching position. The travel of the firing pin backward is therefore increased. By the same token when the triggering sleeve is thrown off, there is more separation between the inertia element and the triggering sleeve. This makes it possible to eliminate the chamber on the back end of the bore in the triggering sleeve. The effect of this change is that the sleeve must travel a greater distance in order to release the firing pin. This, it was felt, reduced the likelihood of releasing the firing pin during set back.

STATIC TESTING

Three types of modified fuzes were made available for static and dynamic testing in accordance with the evaluation of the problems:

1. The double ball design, Drawing No. C8162.
2. The design with a heavy triggering sleeve.
3. The old design with a modified triggering sleeve.

In addition to this inertia elements were lightened by:

a. Enlarging the rear bore.

b. Making aluminum components.

It was still felt that the results of static tests were not 100 per cent conclusive because of the very much lower "g" level available for set back and of the very short duration of the "g" force. A centrifugal fixture was contemplated, but the idea dropped for the time being in order to conserve funds.

A large number of static drop tests were then conducted with the three designs mentioned under 1, 2 and 3 above.

The result of these tests was that design 1 worked every time it was tested while the other designs did not work nearly as well. Design 2 worked only in 1 per cent, design 3 in 40 per cent of the drops.

As previously explained, these tests consist in putting the fuze into a suitable adapter and dropping it on the base. This should set back the triggering components and let the rotor arm. The fuze is carefully examined after each drop and then put back into the adapter and dropped on the nose from a small height. Design C8162 fired the firing pin into the rotor cavity when dropped from 5 1/2". The old design fired when dropped from 4 1/2". This shows a decrease of sensitivity but of too small an order as to cause concern.

Based on the static tests, design 2 was dropped and a dynamic test performed using design 1 and 3. The results of this test are tabulated below:

Round #	Velocity F/S	Temp °F	Fuze Type	Inertia Element	Firing Pin	Triggering Sleeve	Function	Comments
51	345	+ 120	New	Steel	New	Contained	Yes	
52	345	+ 120	New	Alum.	New	Contained	Yes	
53	323	+ 120	New	Steel	Old	Contained	Yes	
54	345	+ 120	New	Alum.	Old	Contained	Yes	
59	335	+ 120	New	Steel	Old	Contained	Yes	
55	335	+ 120	Old	Unchanged	Old	Reduced O. D.	No	Firing pin released & in rotor fuze partly armed
56	335	+ 120	Old	"	Old	Reduced O. D.	Yes	
65	304	- 20	Old	Lightened	Old	"	No	AS No. 55
68	345	- 20	Old	Unchanged	Old	"	Yes	

"Now" fuze means Design C8162 (double ball).

"New" firing pin means Design A8160.

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EVALUATION OF DYNAMIC TEST

Based on the static and dynamic results, it may be stated that the "double ball design" appears to have overcome the problems previously encountered, which showed up again during this test with the old design. A quantity of twenty fuze components using the new design was ordered for a dynamic penetration test with the remaining HEAT heads (E. M. No. 1). This test will be conducted as soon as propellant becomes available.

Drawings were prepared showing a simple modification which will change the old parts into components usable in the new design. More tests will have to be conducted to further establish functioning. As can be seen in the table, the results with aluminum inertia elements were as good as the results with steel inertia elements. This also will have to be confirmed in more tests. Examination of the brinneling marks on the fuze components gives no indication that the functioning time of the fuze has been effected by the changes.

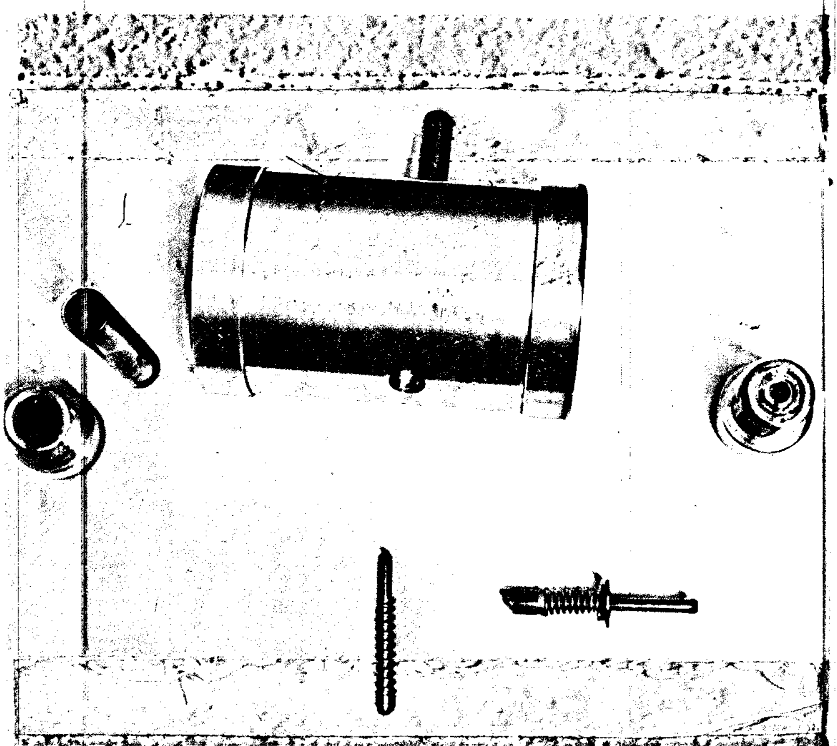
It was found that the new design is considerably easier to assemble than the old one because the shroud around the triggering sleeve prevents the assembler from accidentally separating the sleeve from the inertia element.

A new design will be tried as soon as possible. This will consist of the original idea of using a shroud around the inertia element without use of the balls locking the triggering sleeve.

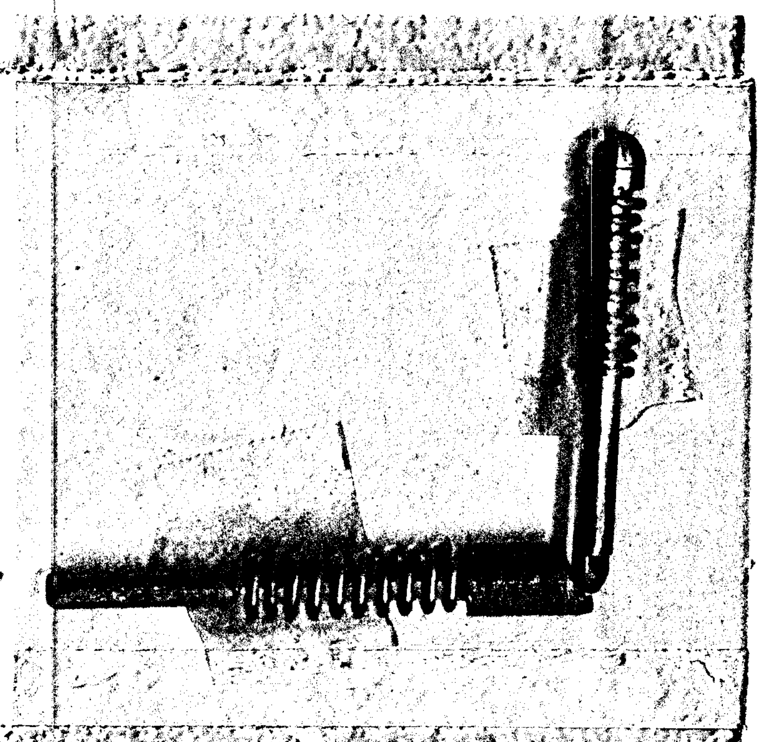
FUTURE PROGRAM

Parts will be manufactured to test more of the new model fuzes. Steps will be taken to modify parts made for the original design. The design not using locking balls for the triggering sleeve but only the shroud will have to be detailed, manufactured and tested both statically and dynamically. Following this, a large test (50 fuzes) will have to be held to check out the design and establish the arming distance. It is anticipated that with the velocity of the round increased to 350 ft/s the arming distance will be in excess of 10 feet.

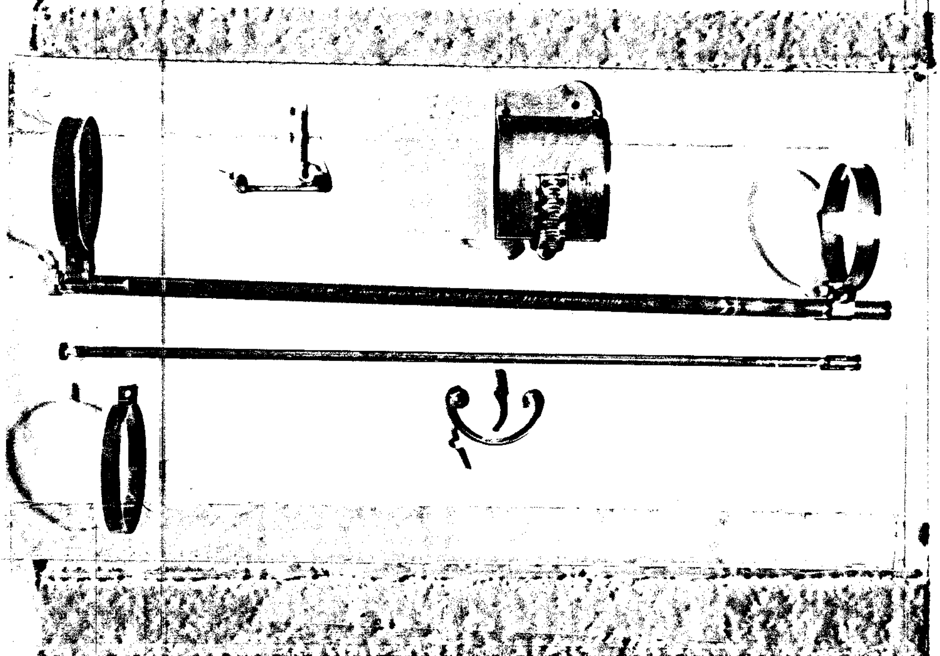
PHOTOGRAPHS



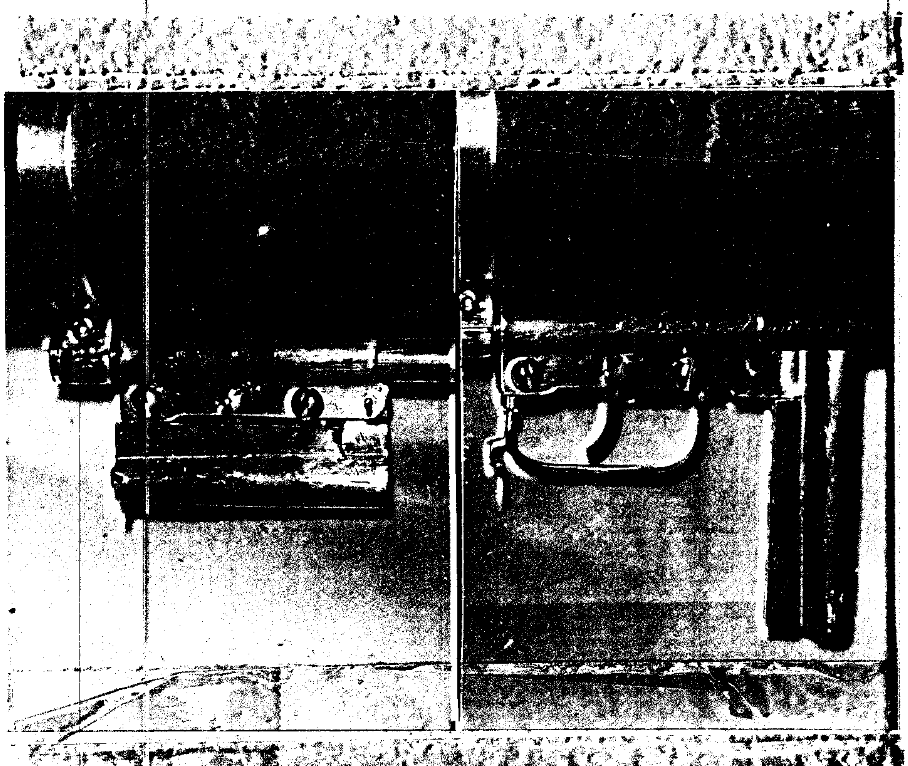
Photograph No. 32
Igniter Test Adapter and Accessories



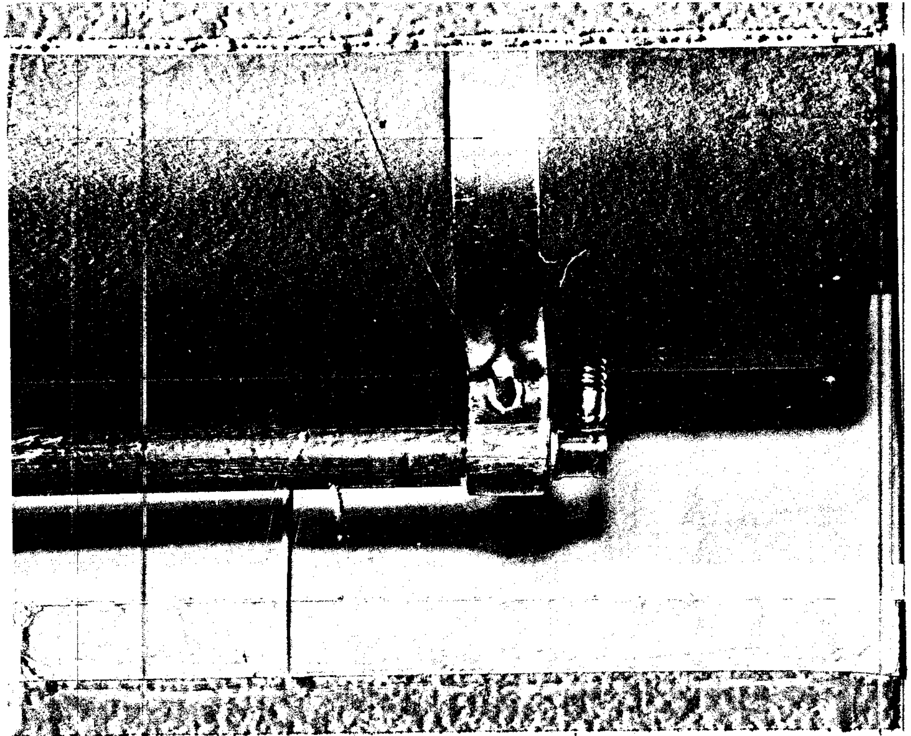
Photograph No. 33
Orientation of Firing Pin and Restraining Plunger



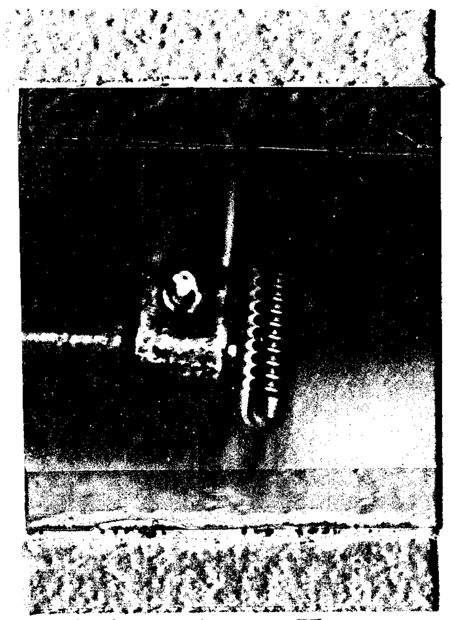
Photograph No. 34
Launcher Components (Sans Safety Handle)



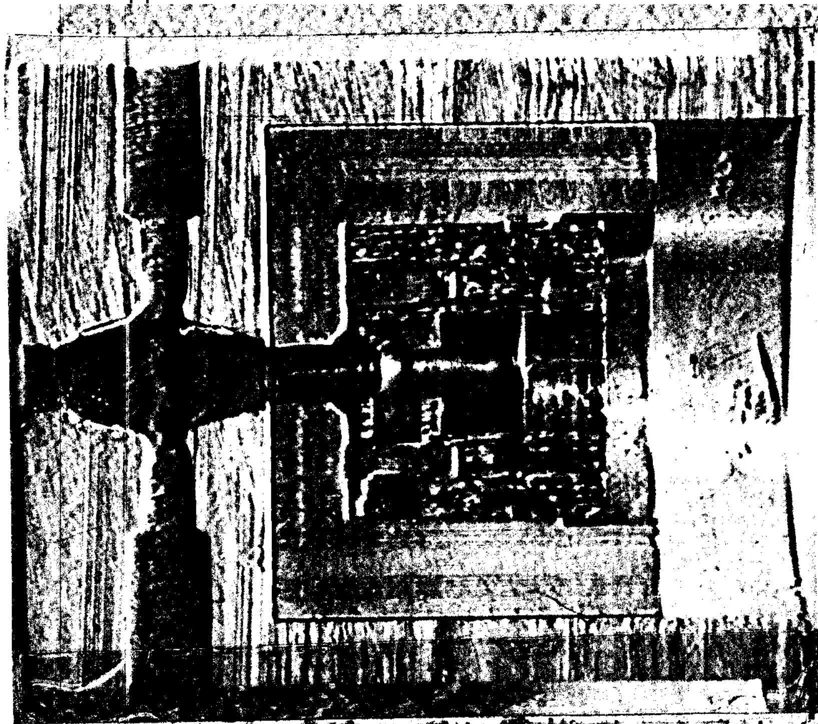
Photograph No. 35
Safety Handle, Left-Storage Position, Right Ready Position



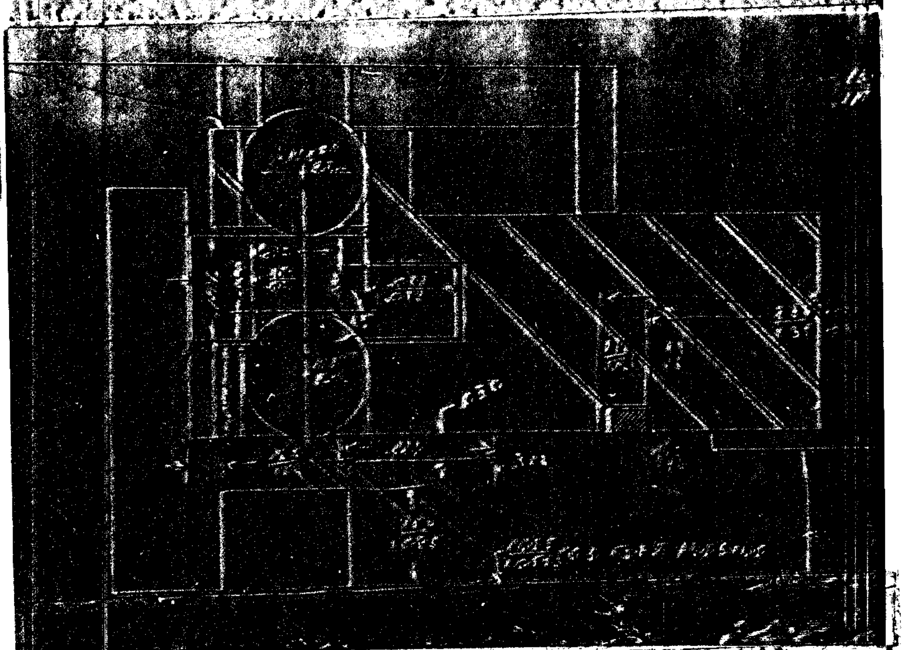
Photograph No. 36
Restraining Plunger Stop - Before Firing



Photograph No. 37
Restraining Plunger Stop - After Firing



Photograph No. 38
Cutaway, Double Ball Design



Photograph No. 39
Drawing No. C8162, Double Ball Design

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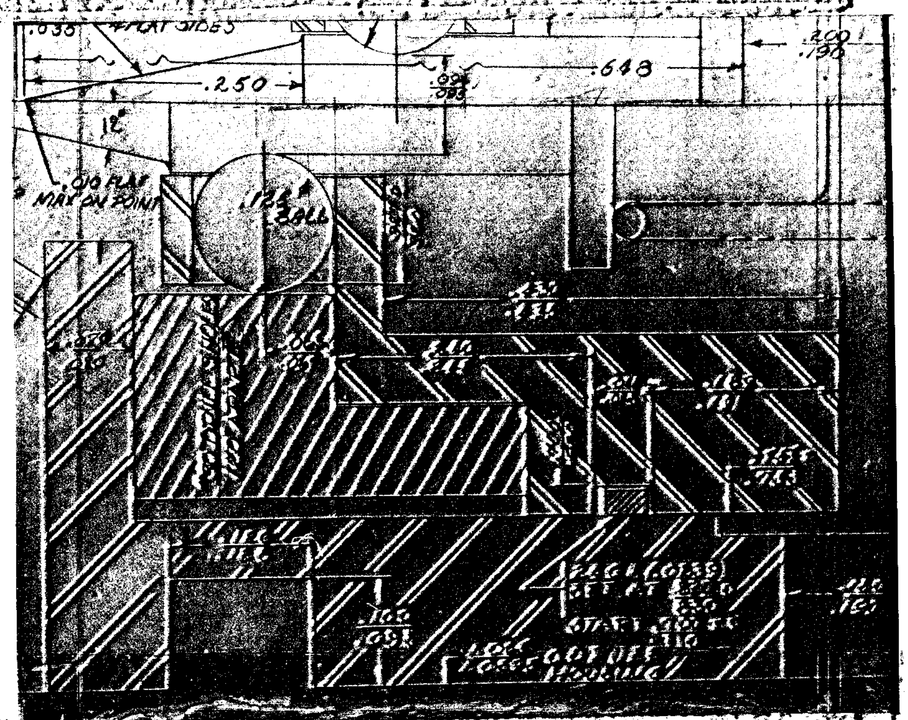
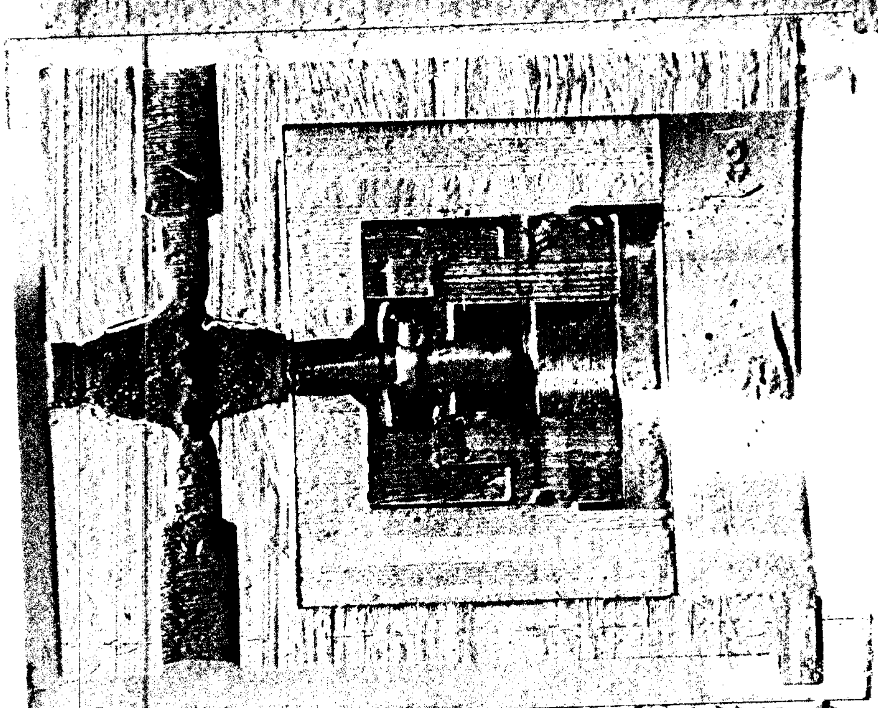


Photograph No. 40
Drawing No. C8157, Heavy Triggering Sleeve Design



Photograph No. 41
Cutaway, Heavy Triggering Sleeve Design

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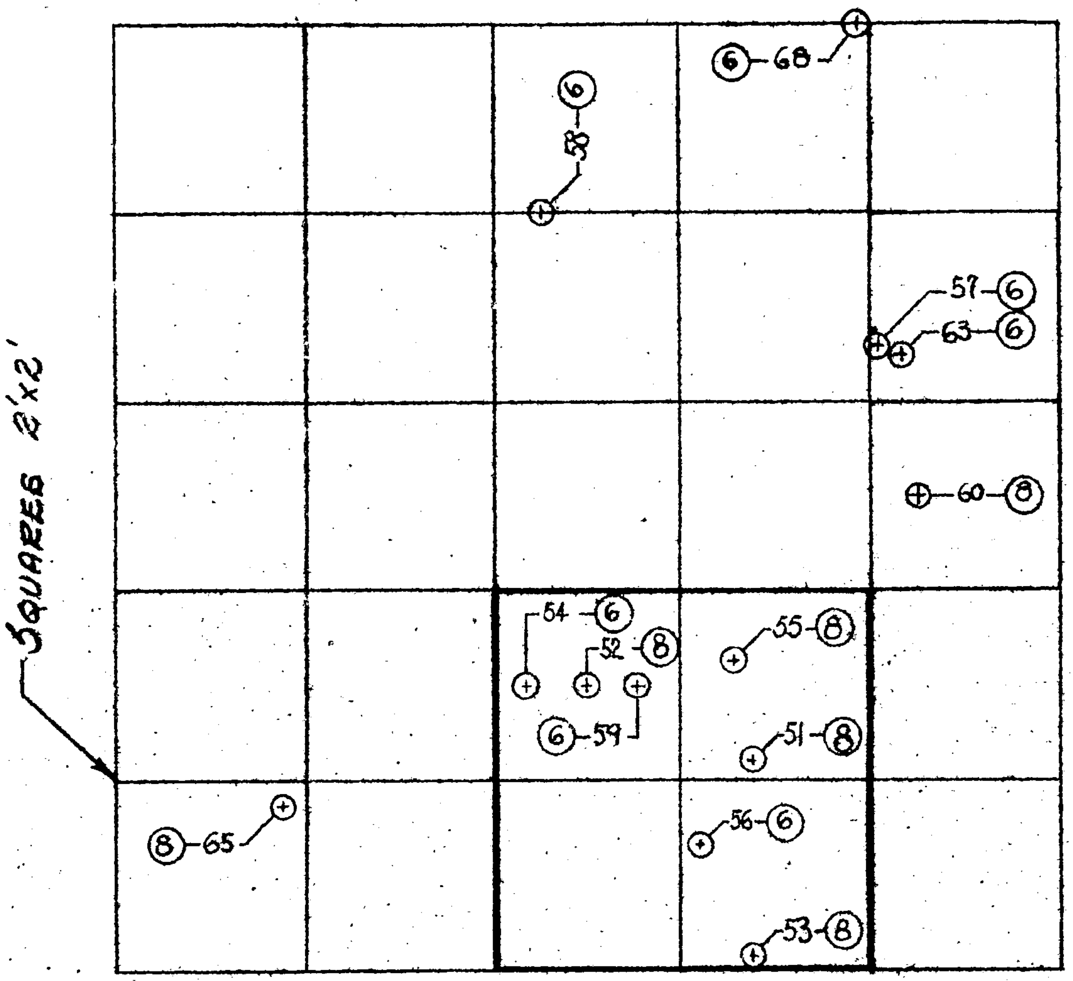

REVISIONS
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ALL DIMENSIONS APPLY AFTER PLATING
125 FINISH ALL OVER EXCEPT WHERE NOTED
BREAK ALL SHARP CORNERS .005—.010
STANDARD TOLERANCES DECIMAL +.005 FRACTIONAL ±1/64 ANGULAR ±1° ALL DIA. ON SAME ℄ TO BE CONCENTRIC WITHIN T.I.R. UNLESS OTHERWISE NOTED

HESSE—EASTERN, DIVISION OF FLIGHTEX FABRICS, INC.
CAMBRIDGE 38, MASS.

TARGET HITS - RANGE 100 yds
TARGET 10'x10' Rds 51 To 68

PROJ. 506-1	ASSY DWG	BY	KW
SCALE 1" = 2'-0"	REF DWG	CH'K'D	
MAT'L		ENG'R	
		APP'D	

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